218 Precipitation Measurement Mission for Improved Forcing in Hyper-Resolution Land Surface Models

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Introduction

Terrestrial energy and water budgets have profound influences on the overall behavior of the climate system. Monitoring and simulation of these processes are critical for many important applications, including agricultural productivity forecasting, flood and drought forecasting, and water resources management. One of the current priority challenges of the hydrological research community is the creation of hyper-resolution (1-km or finer) hydrological simulations on large (e.g. continental) scales [Wood et al., 2011]. In this research, we aim to supplement the next generation of land surface models, at 'hyper-resolution', by creating and demonstrating the next generation high-resolution precipitation forcing combining dynamically downscaled reanalysis data and PMM observations.

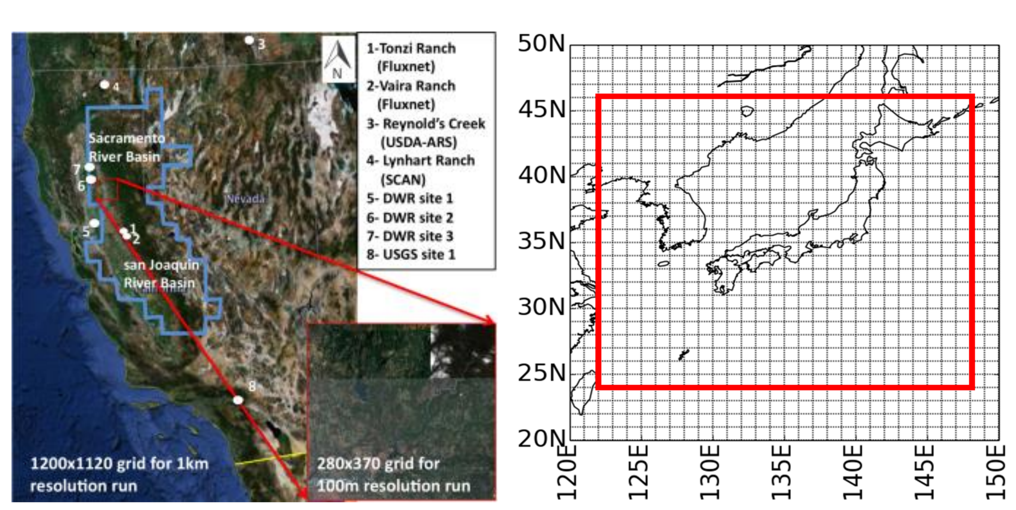
Objectives

We plan to build a test-bed for application of a dynamically downscaled, satellite-based precipitation product in hyper-resolution hydrological simulations and investigate the effect of improved resolutions of meteorological forcing and bias correction on simulation performance.

High resolution forcing data generation
Develop the methodology to blend dynamically downscaled reanalysis datasets and satellite-based precipitation estimates.
High resolution model simulations
Force the 1-km resolution version of the Community Land Model over the Southwestern US with a suite of precipitation at different resolutions.
Force the MATSIRO model at 1-km resolution over the Northeast Asia domain using a suite of precipitation at different resolutions.
Analysis: how does precipitation quality/resolution affect hydrology simulations?
Quantify how the improvement of spatial resolution of precipitation forcing affects the hyper-resolution hydrological simulations.
Quantify how the incorporation of satellite-based precipitation product into the precipitation forcing (i.e. the bias correction) affects the hyper-resolution hydrological simulations.

Methodology

Study Areas. 1) Southwestern U.S. (incl. California, Nevada, and parts of Oregon, Idaho, Utah, and Arizona) : 113.3°E–124.5°E × 31.4°N–43.4°N (1200 × 1120 grid cells, each 0.01°)
2) Northeastern Asia (incl. Japan and Korea) : 123.0°E–148.0°E × 24.0°N–46.0°N (2500 × 2200 grid cells, each 0.01°)



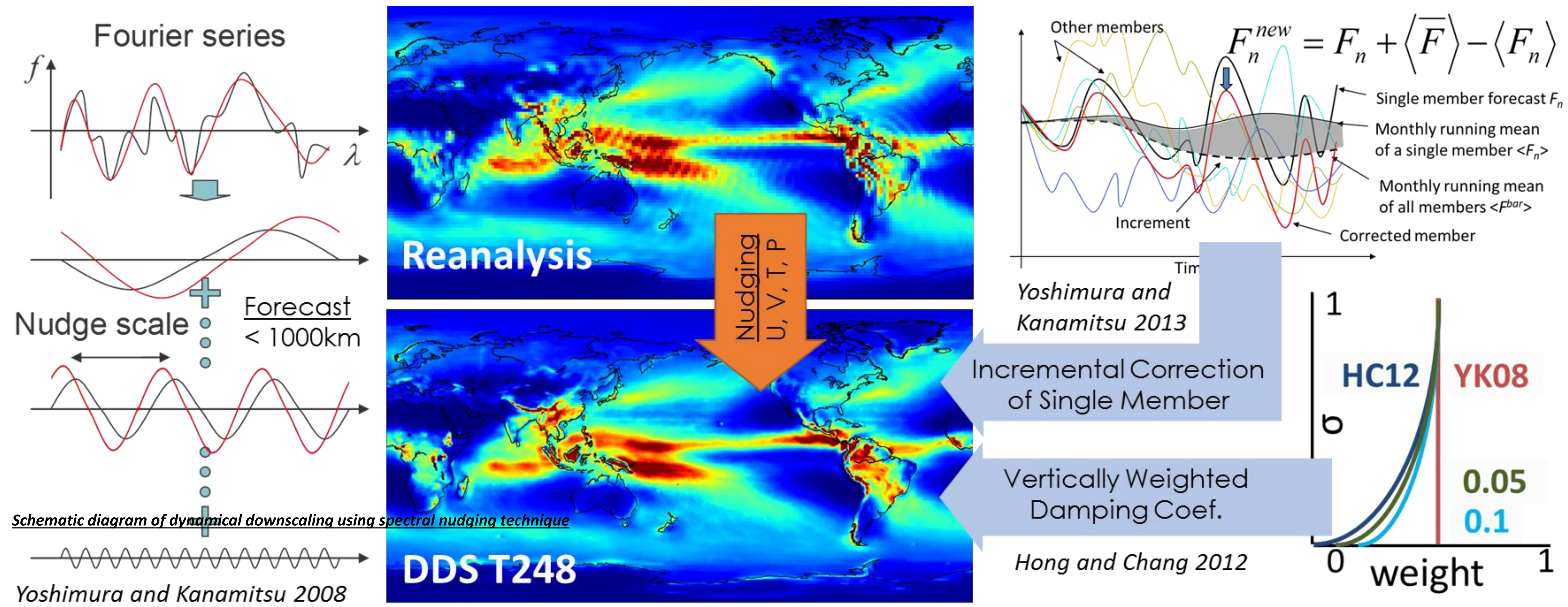
Study areas: Southwestern U.S. (left) and Northeastern Asia (right)

Dynamical Downscaling. State of the art atmospheric reanalysis data (e.g., JRA55, ERA-Interim, and MERRA) is available globally for every 3 or 6 hours in near real time. Their spatial resolutions are approximately half degree, which should be too coarse to be exploited as-is in hyper-resolution simulation (~1km). Scale-selective bias correction (SSBC) scheme [Yoshimura and Kanamitsu, 2008] is proposed to disaggregate original reanalysis data using a Regional Spectral Model (RSM). Dynamic fields (i.e., zonal and meridional wind) in the low frequency domain are constrained by original reanalysis data by using a spectral nudging scheme as follows:

$$f_{(\lambda,\phi)} = \sum_{m=-M}^{m=M} A_{(m,\phi)} e^{im\lambda}, \qquad with$$

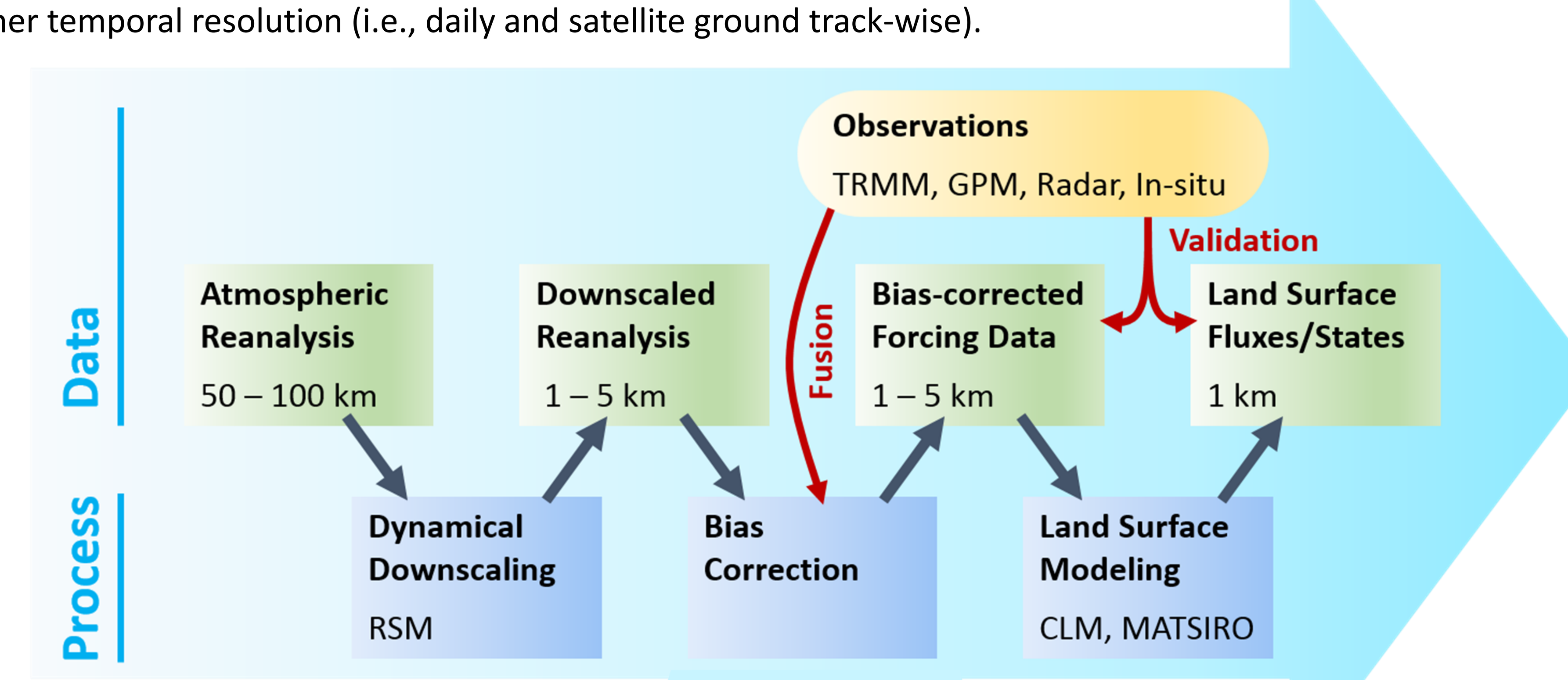
$$A_{(m,\phi)} = \begin{cases} A_{RSM(m,\phi)} & \left(|m| > \dfrac{2\pi R_E \cos\phi}{L}\right) \\ \dfrac{1}{\alpha+1}\left[A_{RSM(m,\phi)} + \alpha A_{RA(m,\phi)}\right] & \left(|m| \le \dfrac{2\pi R_E \cos\phi}{L}\right) \end{cases},$$

where f is a full field of physical variable, A is the Fourier coefficient, and the subscripts RSM and RA indicate RSM forecast and original atmospheric reanalysis, respectively. λ, ϕ, R_E, m, M, α, L indicate longitude, latitude, radius of the earth, wavenumber, truncation wave number, nudging coefficient and critical nudging scale where waves longer than L will be nudged.

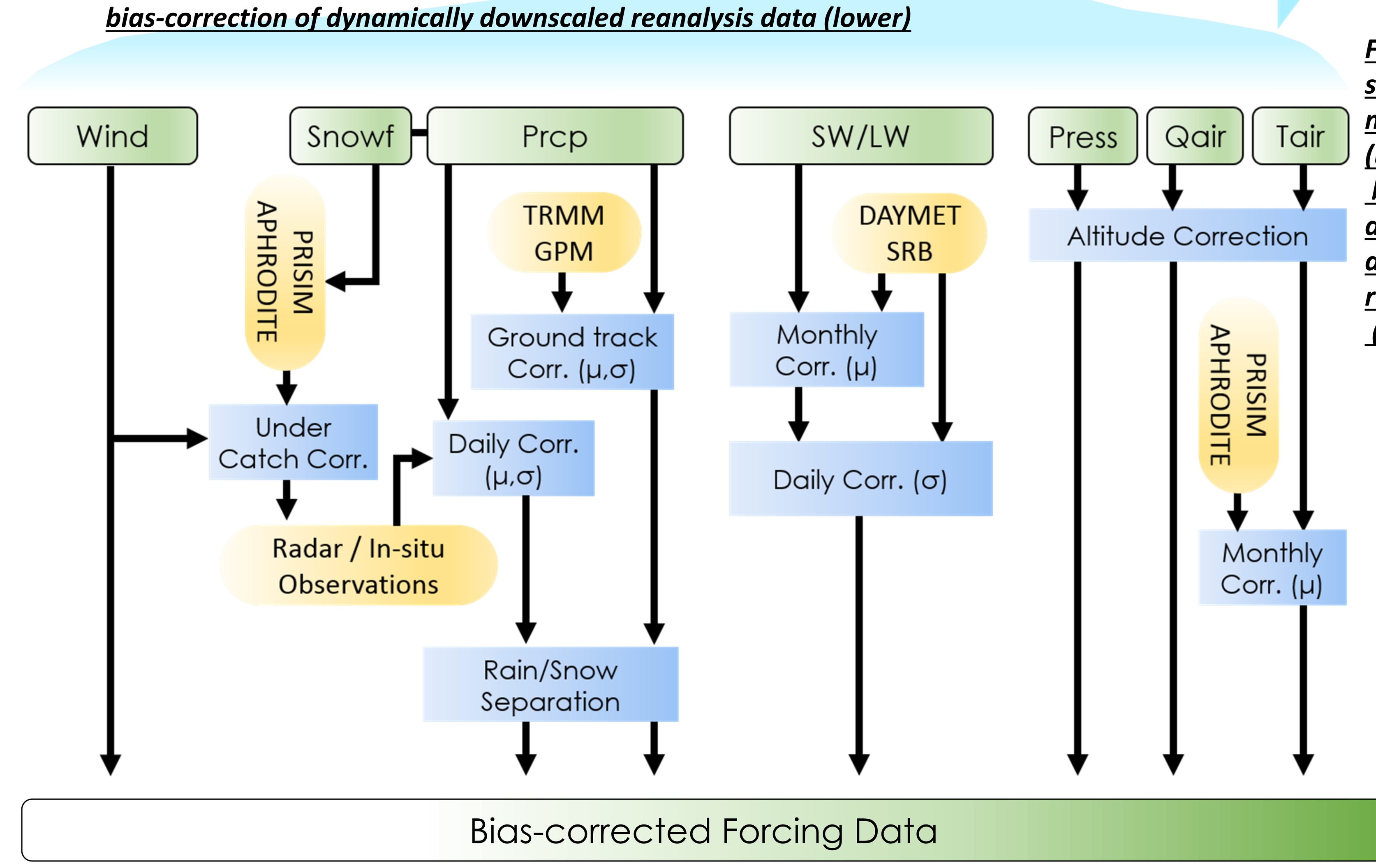


Schematic diagram of dynamical downscaling using spectral nudging technique

Blending Observations to Downscaled Reanalysis. Retrospective atmospheric boundary conditions in 3-hourly resolution will be generated. Model biases in the downscaled reanalysis data are corrected blending with observational data [e.g., Kim et al., 2009; Kim, 2016]. Additionally, new methods will be developed and tested to correct variability in higher temporal resolution (i.e., daily and satellite ground track-wise).



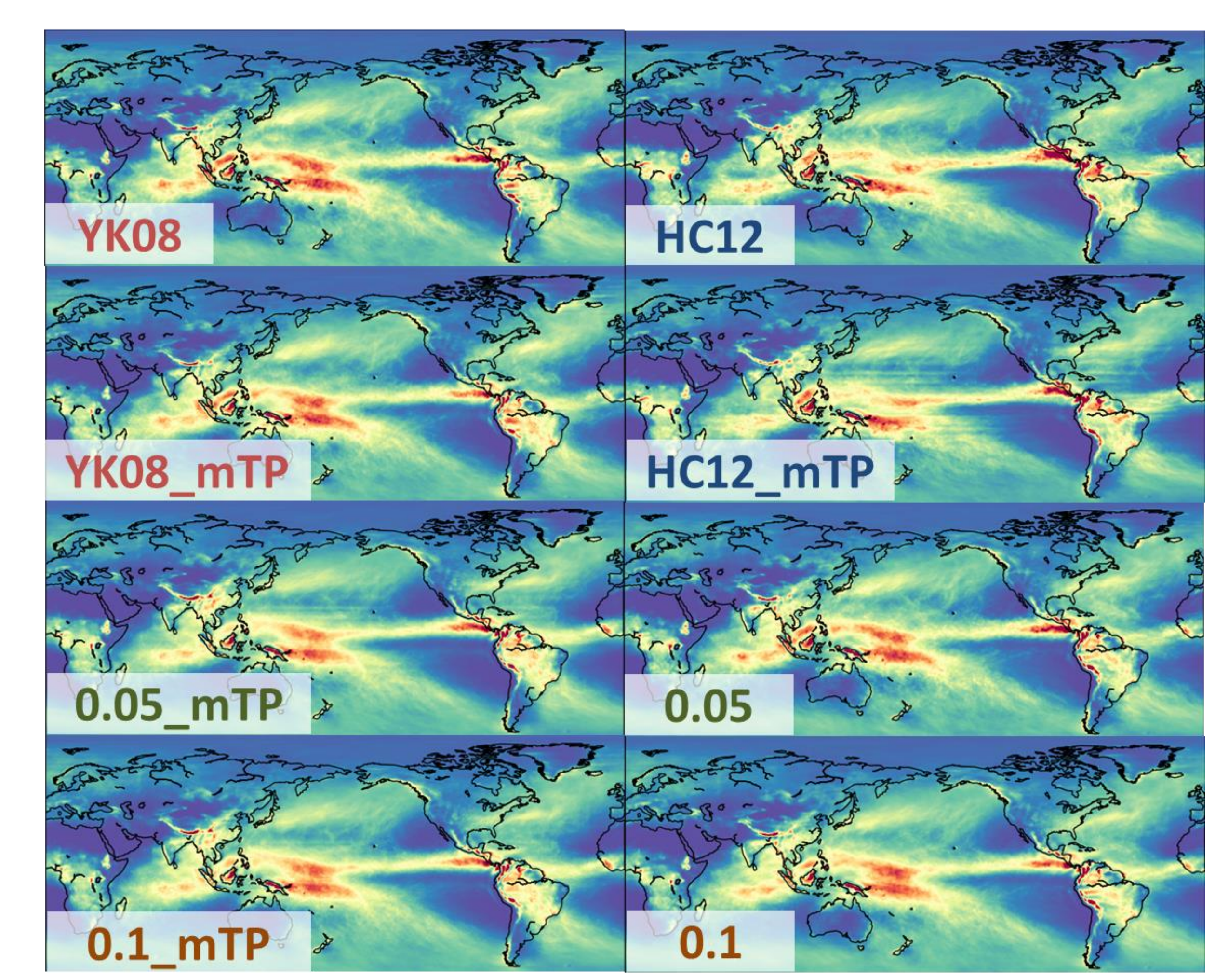
Flow chart for the sequence of data-model integration (upper) and bias-correction of dynamically downscaled reanalysis data (lower)



Flow chart for the sequence of data-model integration (upper) and bias-correction of dynamically downscaled reanalysis data (lower)

Preliminary Results

Sensitivity Tests. To find optimal configuration of dynamical downscaling, different curves for vertical damping coefficient profiles and nudge scales for temperature and pressure were tested. Also, different convective schemes (e.g., SAS, RAS, KF2) were evaluated in terms of the reproducibility of diurnal cycles (not shown here).



Preliminary results of sensitivity tests for optimal configuration of dynamical downscaling

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